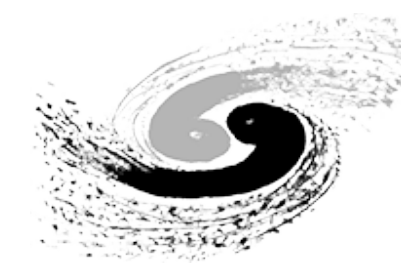


Prospects for Precision YN and $\bar{n}N$ Measurements with an LH_2/LD_2 Target in the BESIII Detector



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Introduction

Physics motivation

- YN extends NN to strangeness: **SU(3) flavour breaking, hypernuclei, hyperons in neutron stars.**
- YN data are sparse: mostly 1960s–70s bubble chambers, plus J-PARC E40 (Σ^+p) and CLAS (Λp).
- Chiral EFT predictions currently reach ~ 0.9 GeV/c. Our Λ (1.07 GeV/c) and Σ^+ (0.99 GeV/c) beams uniquely test its limits: **differential** data there probe the coupled ΛN – ΣN interaction.
- $\bar{n}p$ is a pure **isospin** $I = 1$ system without Coulomb interaction; charge-exchange $\bar{n}$ beams (BNL E767, OBELIX) reached only ~ 0.5 GeV/c.

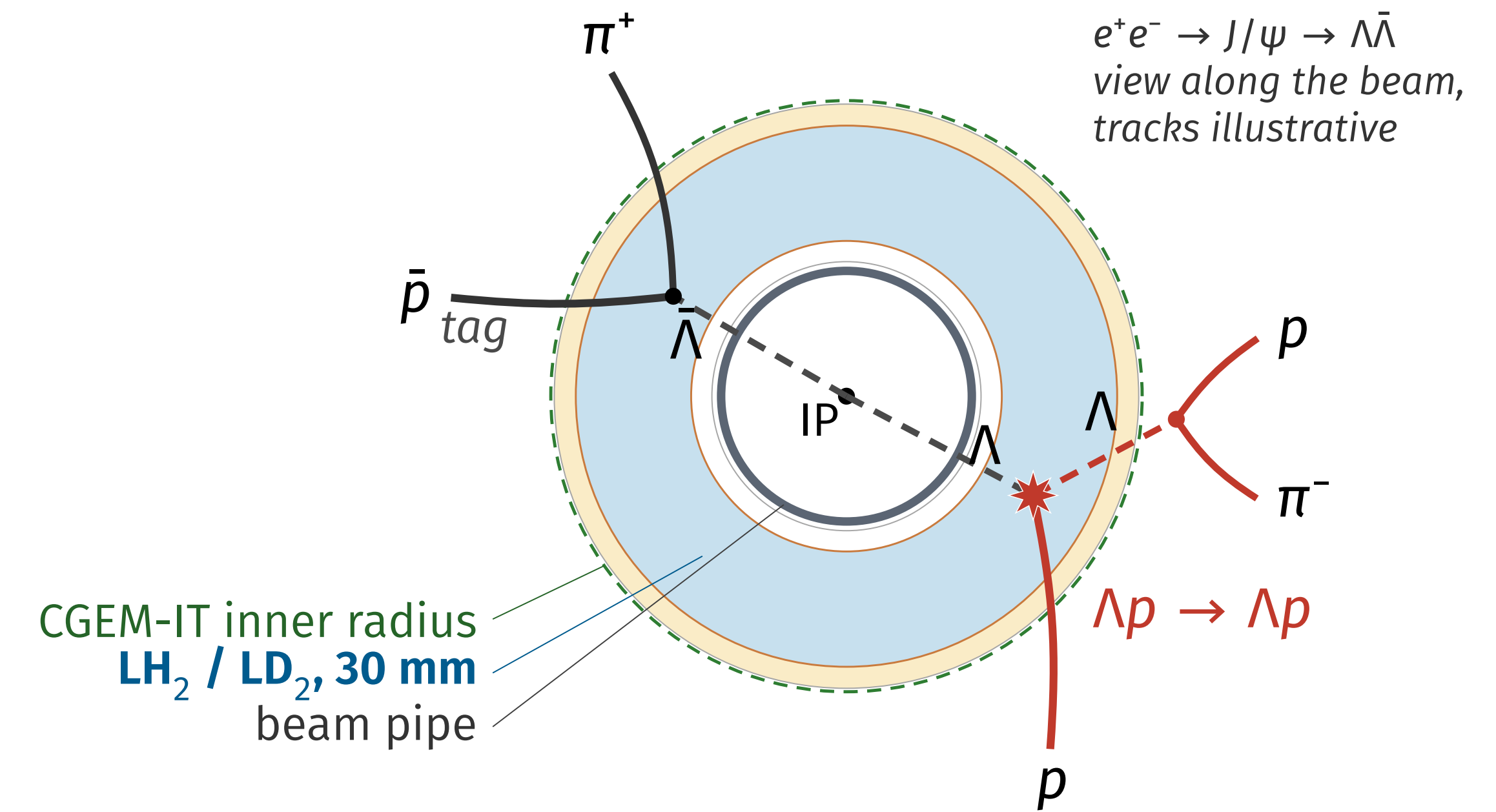
Tagged beams at BESIII

- J/ψ , $\psi(3686)$ decays give **tagged** beams: the recoil system fixes each beam particle's momentum and direction, and the tag strongly suppresses background.
- Published BESIII measurements use the **beam pipe** as target: free protons only in a 0.8 mm cooling-oil layer (low statistics); Be/C/Au nucleons need nuclear-model corrections.

Beam Source	Λ	Σ^+	Ξ^-	Ξ^0	Ω^-	$\bar{n}$
p (MeV/c)	1074	992	807	818	774	0–1174

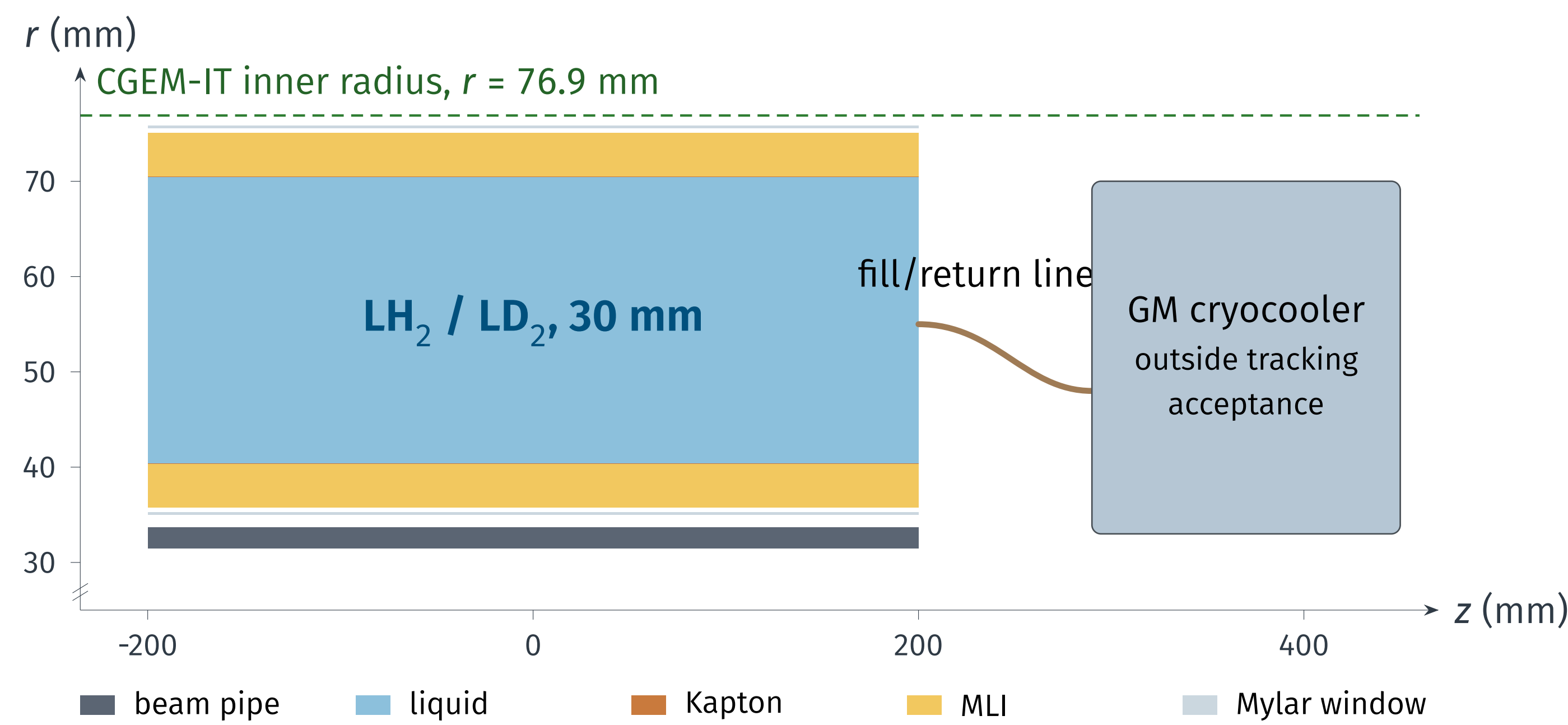
The idea

An LH_2/LD_2 target between beam pipe and CGEM



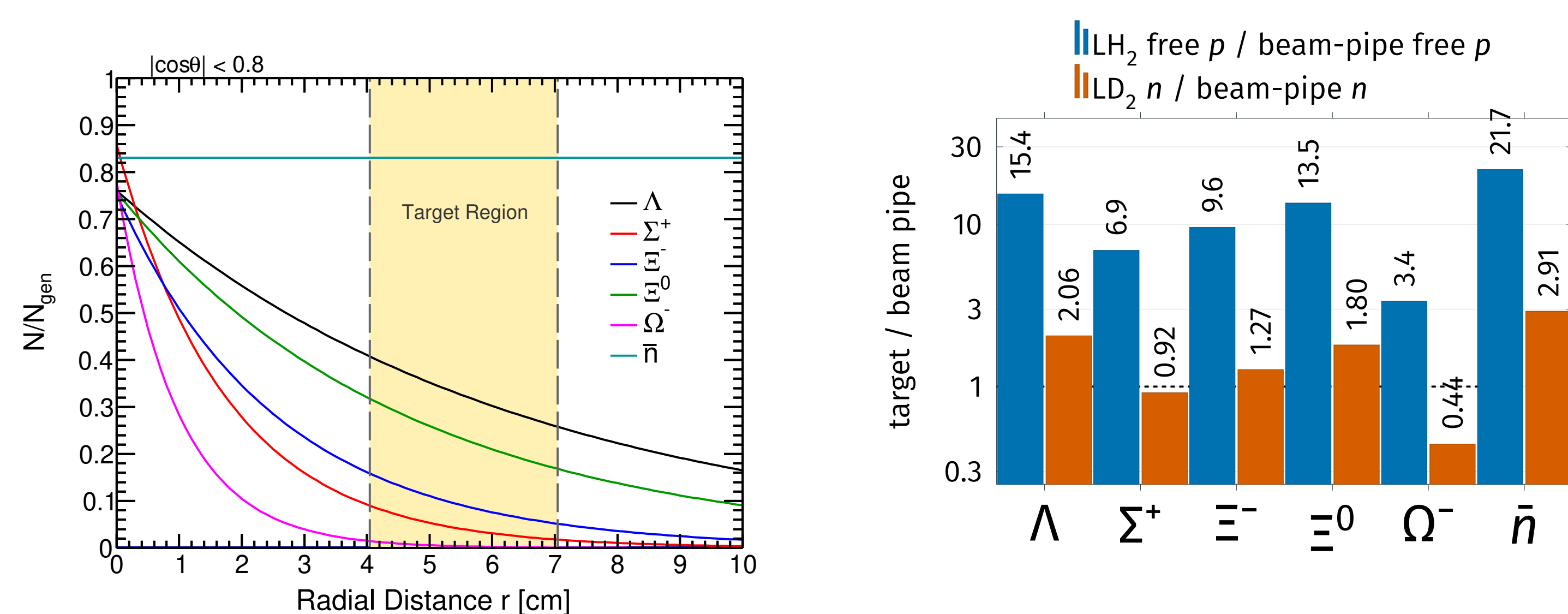
The LH_2/LD_2 target

Geometry and materials



- 30 mm liquid at $40.4 < r < 70.4$ mm, between beam pipe and CGEM-IT.
- LH_2 (0.071 g/cm³): free protons. LD_2 (0.164 g/cm³): neutrons in the simplest nucleus.
- 0.1 mm Kapton walls contain the liquid; aluminized-Mylar MLI blocks radiant heat; thin Mylar windows close the insulating vacuum.

Effective target density

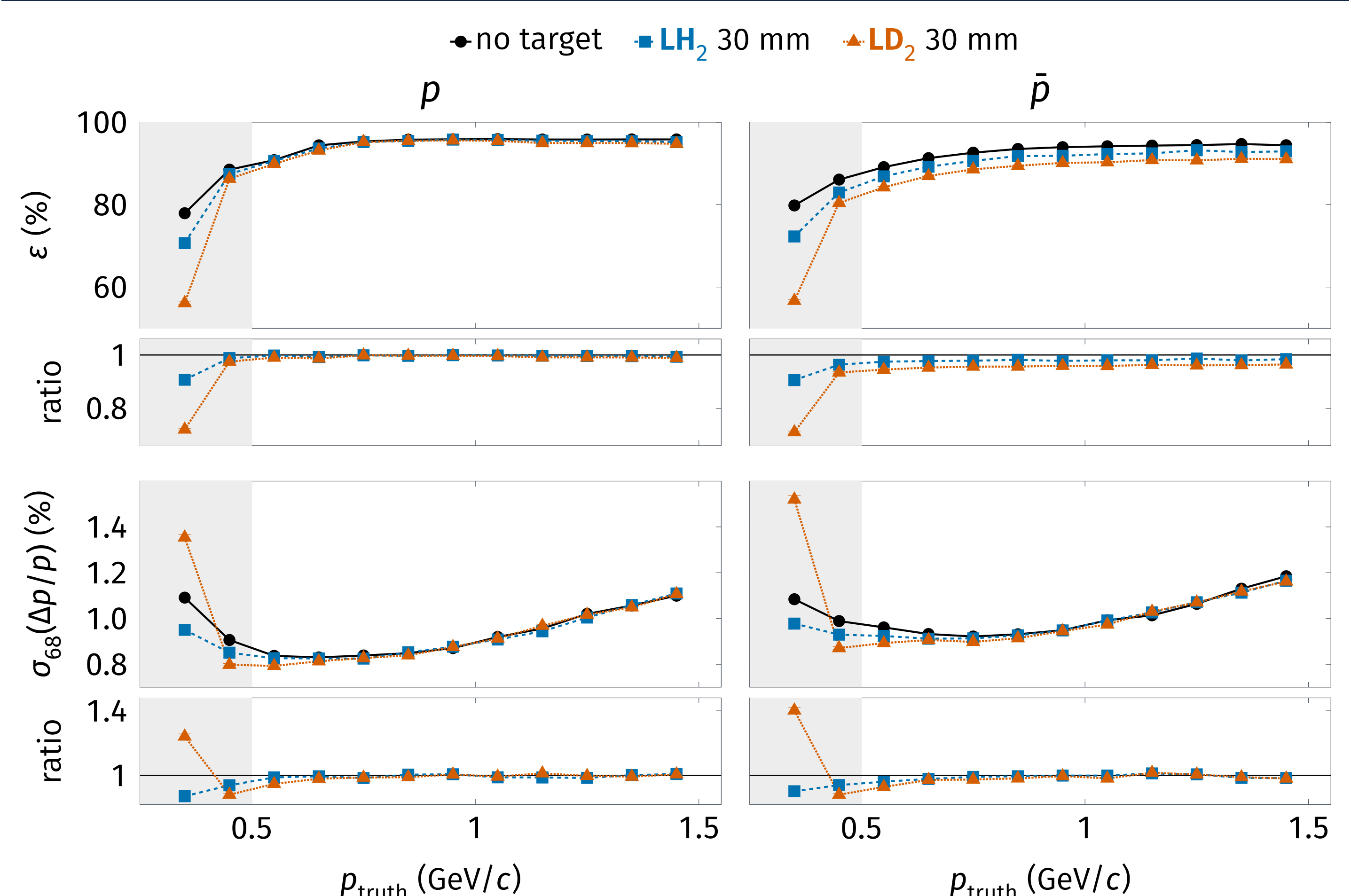


Accepted surviving fraction vs. radius; yellow: target.

- $T_Y = N_A \rho \langle l \rangle_Y / M$, with the decay-weighted path $\langle l \rangle_Y$ ($|\cos \theta| < 0.8$).
- LH_2 : 7–22× the free-proton density of the beam-pipe cooling oil.
- LD_2 : 0.9–2.9× beam-pipe neutron density, on the deuteron instead of Be/C/Au.
- Ω^- mostly decays before reaching the target (3.4× and 0.44×).

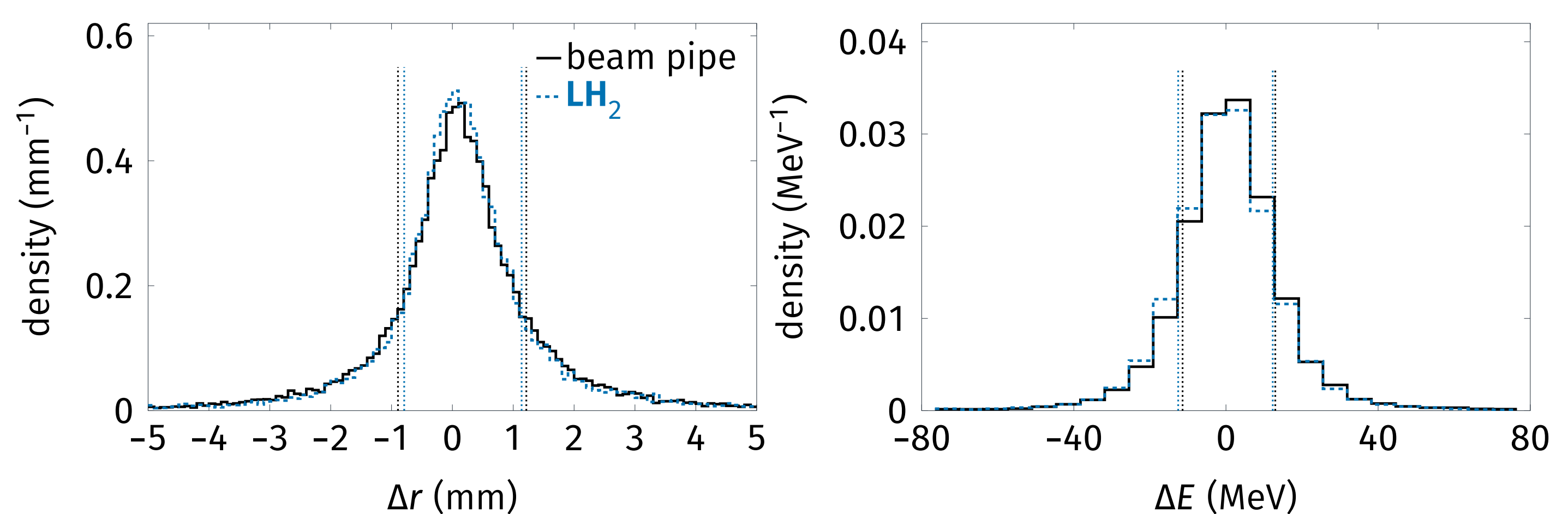
Impact on tracking

Single particles



- Changes appear mainly below 0.5 GeV/c; above it, p , K , π efficiencies stay within 1.2 (LH_2) / 1.6 (LD_2) percentage points of the baseline.
- $\bar{p}$ efficiency drops by 1.2–2.2 / 3.4–4.9 points, from annihilation in the liquid.

Full event: $J/\psi \rightarrow p\pi^-\bar{n}$, $\bar{n}p \rightarrow 2\pi^+\pi^-$



- Selection efficiency 27.3% (beam pipe) $\rightarrow$ 23.6% (LH_2): ratio 0.864 ± 0.007 .
- Comparable resolution: $\sigma_{68}(\Delta r) = 1.05 \rightarrow 0.96$ mm, $\sigma_{68}(\Delta E) = 12.2 \rightarrow 12.4$ MeV.

Projected yields per year

Channel (LH_2)	beam pipe (published)	LH_2 / yr
$\Lambda p \rightarrow \Lambda p$	61	1765
$\bar{\Lambda} p \rightarrow \bar{\Lambda} p$	72	2087
$\bar{n} p \rightarrow 2\pi^+\pi^-$	59	2417
$\bar{n} p \rightarrow 2\pi^+\pi^-\pi^0$	182	7454
$\bar{n} p \rightarrow 2\pi^+\pi^-2\pi^0$	98	4002

1.9×10^{10} J/ψ /yr. Published BESIII free-proton channels, scaled by 1.88 (J/ψ events) $\times 15.4$ / 21.7 (density); same efficiency assumed.

- 29–41×** the published beam-pipe samples; statistical errors 1.2–2.4%, below published systematics (7.5–9.1%) $\rightarrow$ differential measurements.
- LD_2 : $(1.8\text{--}2.7) \times 10^3 \Sigma^+n$, $8.1 \times 10^3 \Xi^0n$ raw interactions/yr; trades nuclear-ratio (7.2–7.3%) and Fermi-motion (6.5–12.8%) systematics for deuteron corrections.

Summary and outlook

A promising concept for higher-statistics YN and $\bar{n}N$ scattering.

- Target:** LH_2 7–22× free-proton density; LD_2 : deuteron instead of Be/C/Au.
- Tracking:** changes mainly below 0.5 GeV/c; $\bar{n}p$ efficiency ratio 0.86.
- Physics reach:** 29–41× published free-proton yields per year for Λ , $\bar{\Lambda}$, $\bar{n}$.

Outlook

- More tagged channels:** e.g. $J/\psi \rightarrow \bar{p}K^+\Lambda + \text{c.c.}$, p_Λ 0–0.9 GeV/c.
- Room-temperature targets:** $(CH_2)_n$, $(CD_2)_n$, LiH, D_2O .
- Future facilities:** STCF, SCTF, with larger J/ψ samples.